SPLENIC-GONADAL FUSION *

WALTER G. J. PUTSCHAR, M.D., and WILLIAM C. MANION, M.D.
From the Department of Pathology, Charleston General Hospital, Charleston, W. Va. (Dr. Putschar) and Armed Forces Institute of Pathology and Veterans Administration Central Laboratory for Anatomical Pathology, Washington, D.C. (Dr. Manion)

Abnormal connections between the spleen and the left gonad or the derivatives of the left mesonephros have been observed occasionally. The first detailed description of such an instance was published by Pommer[1] (1889), who mentioned a similar observation demonstrated by Bostroem,[2] which apparently was published only by title. Union of the spleen with the gonadal-mesonephric structures as a teratologic syndrome was first described by one of us (W. P.[3]) in 1934, in a monograph including all cases of this entity which had appeared in the literature up to that date.

In the older reports, splenic-gonadal fusion had been undetected until recognized incidentally at necropsy. Beginning with Heitzmann[4] (1917), however, clinical recognition of the anomaly, both before and at the time of surgical intervention, has been reported with increasing frequency. The best summary of these observations in the American literature was by Emmett and Dreyfuss[5] (1943). The first successful removal of a splenic cord and attached testicle was reported by Bennett-Jones and St. Hill[6] in 1952.

The purpose of this paper is to survey all the published cases, to add 4 new cases, and to discuss the underlying embryologic and teratologic problems. The condensed observations on all cases are arranged in chronologic order. The cases in the literature with our own added total 30.

CLASSIFICATION AND SEX DISTRIBUTION

The anomaly occurs in two forms, allowing division of the cases into two major subgroups: 1. Continuous splenic-gonadal fusion in which a continuous cord-like structure connects the spleen and the gonadal-mesonephric structures; 2. Discontinuous splenic-gonadal fusion in which the fused spleno-gonadal-mesonephric structures have lost continuity with the main spleen and appear as a special variant of accessory spleen. Seventeen of the total published cases and one of our own fall into group 1 (continuous), and 9 published and 3 of our own cases in group 2 (discontinuous). The splenic-gonadal fusions, as would be expected, involved the left gonad in all cases with the possible exception of that of Gordeef and Cuenant,[26] who described a right scrotal enlargement at preoperative examination, but did not state specifically

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which gonad was involved in the fusion. The sex distribution of this congenital anomaly strongly favors the male. Fifteen of the 18 cases of continuous fusion and all 12 cases of discontinuous fusion were in the male, while only 3 instances of continuous fusion were in the female. This is a male-female ratio of 9 to 1. All patients were white except the one reported by Sneath,[8] and he was a Negro.

Condensed summaries of the reported cases and of our own follow.

SPLENIC-GONADAL FUSION

A. CONTINUOUS TYPE: SUMMARY OF 18 CASES

1. Bostroem,[2] 1883. White male, age not given. Fusion of spleen and left testicle with normal location of both organs. Only title listed; no details.

2. Pommer,[1] 1889. White male, newborn. Left testicle undescended in iliac fossa, with dorsal mesorchium; right testicle in scrotal sac; cord of splenic tissue from upper pole of normally located spleen to left epididymis; splenic vessels normal; left spermatic vein received a branch from lower part of splenic cord and opened into left renal vein; a second left spermatic vein originated from testis, anastomosing with first and opening into inferior vena cava. The cord was 5.5 cm. long and 3.5 to 6 mm. wide. Other anomalies were: Perobrachius apus (partial defect of arms with rudimentary humerus only on left); complete absence of both legs and hip joints; micrognathia; atresia of anus; defect of coccyx.

3. Albutt and Rolleston,[7] 1908. Male. Splenic process bound down to posterior abdominal wall by peritoneum and extending to left scrotum.

4. Sneath,[8] 1913. Adult male, Negro. Thin splenic cord arising from upper pole, with rounded nodular portion, 2 by 1 cm., attached to left testicle and spermatic cord, almost covered by tunica vaginalis (Text-fig. 1); histologically normal spleen; the cord was 33.4 cm. long, tapering from 10 to 1 mm. in thickness. *Clinically* interpreted as a third testicle.

5. Heitzmann,[4] 1917. White male, 25 years old. Left indirect inguinal hernia, with patent canal of Nuck and fibrosed splenic cord attached to upper pole of testicle; the cord was 43 cm. long, had a nodular splenic thickening of 2.5 cm. at its lower end, contained histologically normal splenic tissue, received two arteries and one vein from abdominal wall through adhesions, traversed abdominal cavity anterior to small intestines, and disappeared below splenic flexure of colon. Found during repair of left inguinal hernia.

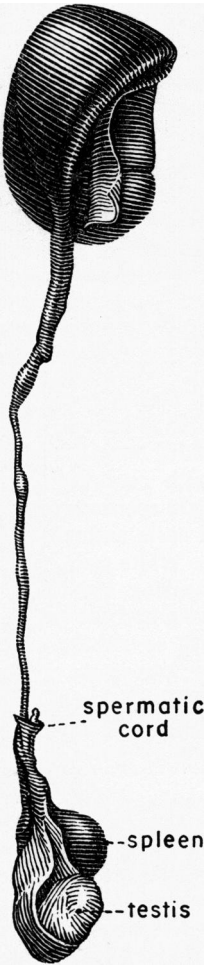
6. Skworzoff,[9] 1924. White male, 10 years old. Cord from lower pole of spleen, passing anteriorly to small intestine through abdominal cavity to left testicle and epididymis, enveloping the hypoplastic testicle; upper two thirds was splenic tissue, lower one third, fibrous tissue; both testicles at external inguinal ring. Other anomalies were absence of right leg except rudimentary head of femur and finger-like skin appendage; absence of left lower leg and foot, including patella; normal left femur with finger-like skin appendage in left knee area. Cause of death: typhoid fever.

7. Wiltschke,[10] 1929. White female, newborn. Splenic cord from upper pole to left mesosalpinx and left mesovarium passing ventral to the intestines. Cord, 77 mm. long, 0.5 to 2.5 mm. wide, with thickened splenic tissue in lower pole.

8. Fischer and Gissel,[11] 1935. White male, 11 years of age. Round splenic cord, about 2 mm. wide, to epididymis of left inguinal testis with hernial sac; free cord traversing abdomen anteriorly without adhesions; upper end of cord and spleen not investigated; histologically normal splenic tissue rich in lymph follicles, slight perifollicular hemorrhages, and increased eosinophils; no blood pigment or fibrosis;

slight hyaline thickening of arteries. No associated anomalies observed at subsequent operation for right inguinal testis. Found during surgical intervention for undescended testicle.

9. Kadlic,[12] 1943. White male, 19 years old. Pear-shaped mass, 4.6 by 2.2 by 1.5 cm., in left scrotum, attached by thin, fibrous cord from its lower surface to upper pole of left testicle, with a 9 cm. cord arising from its upper surface and passing through left inguinal canal; resembled spleen grossly; substantiated microscopically by presence of splenic pulp, lymph follicles, cords, and sinusoids containing



Text-figure 1. Drawing of the splenic-gonadal fusion in the case reported by Sneath.[8] (Redrawn from Sneath, W. A. An apparent third testicle consisting of a scrotal spleen. *J. Anat. & Physiol.*, 1912–13, **47**, 340–342. By permission of the Cambridge University Press.)

few erythrocytes. Upper portion of cord consisted of splenic tissue with one large artery and vein attached. Cord between spleen and testicle was fibrous, vascular, with some fatty tissue and one larger central artery and vein. Surgical specimen. Clinical diagnosis: congenital left inguinal hernia with aberrant spleen.

10. Olken,[13] 1945. White male, 56 years of age. Spleen, 200 gm., normal position; from upper pole, a splenic cord, 0.3 cm. to 0.5 cm. in diameter, passing through abdominal cavity laterally, joining left spermatic cord at inguinal ring, terminating as a bulbous mass (1.8 by 1 by 1 cm.), attached to tunica albuginea at head of left epididymis and completely covered by tunica vaginalis; accessory spleen 0.8 cm. in diameter near splenic hilus; histologically, typical splenic tissue with inflammatory hyperplasia of pulp as in spleen. Cause of death: peritonitis from perforated, bleeding, duodenal ulcer.

11. Andrews and Etter,[14] 1946. White male, 32 years old. Splenic cord with "marble-sized" enlargement at lower end of left spermatic cord; surgical exposure of testicle and cord only; 12 cm. of splenic cord which entered the inguinal canal removed; abdomen not opened; spleen not examined; histologically, normal splenic tissue in cord with slight hyperplasia of germinal centers and superficial organized thrombosed veins. Admitted with pain in left testicle and scrotum; left enlargement had been noticed since birth; particular discomfort during heavy exercise.

12. Tate and Goforth,[15] 1949. White male, 21 years of age. Splenic mass, 7 by 4 by 4 cm., attached to atrophic left testicle with tail-like process along the spermatic cord, 10 cm. removed; upper portion and spleen not investigated; abdomen not explored; histologically, normal splenic tissue attached to atrophic testis without spermatogenesis and with increased fibrous tissue and Leydig cells. Swelling first noticed at age of 3 years, after operation for left undescended testicle; mass occasionally tender since; patient well 13 years after second operation.

13. Keizur,[16] 1952 (case 2). White male, 69 years old. Bilobed spleen with beaded (alternating splenic and fibrous tissue) cord from lower pole through abdomen, joining left spermatic cord at internal inguinal ring and ending with splenic mass (2 cm. in diameter) embedded beneath albuginea in upper pole of left testicle; histologically, normal spleen with considerable free pigment, separated by thin, fibrous layer from testis with slight spermatogenesis. Cause of death: fall from tree; dead on arrival with rupture of aorta and mediastinal hemorrhage.

14. Arnett,[17] 1951 and 1953. White male, 13 months old. Tapering process from anterior margin of spleen, traversing abdominal cavity to otherwise normal left testicle, containing artery and vein and accessory spleen in midportion of the cord-like process. Sudden death with convulsion in cyanotic attack. Ectromelia with absence of right lower extremity; two upper extremity stumps, each containing only 2 cm. of humerus. Absence of left femur and fibula. Tibia attached in a ball of muscle at acetabulum. Foot contained three normal and one subnormal metatarsal bones and had four toes. Bones of pelvis normal. (Details to be published by S. D. Wu.)

15. Bennett-Jones and St. Hill,[6] 1952. White male, 10 years of age. Splenic cord (8 inches in length) from hilum of normal spleen, passing through peritoneal cavity, without mesentery. Width, 0.5 inch at upper end, narrowing in middle third to 0.25 inch, expanding at testis to 0.5 inch with little macroscopic demarcation between it and testis. Histologically, normal spleen in proximal and distal thirds of cord, increased fibrous tissue in middle third. Well defined fibrous band separated splenic tissue from main mass of testicular tissue. In one area, a group of seminiferous tubules lay on splenic side immediately surrounded by splenic tissue. Seminiferous tubules normal for patient's age; rete testis and efferent ducts distorted and compressed. Patient first seen at 7 years because of tender, enlarged left testicle; right testicle normal but retractile. Left testicle enlarged, left spermatic cord thickened. Clinical diagnosis: partial torsion or thrombosis of the spermatic cord. Returned 3 years later because of recurrence of left inguinal pain aggravated by exercise. A diagnosis of diffuse lymphangioma of the cord was suggested. Congenital hernial sac present.

16. Werthemann* and Roulet,[18] 1954. White male, 6 months old (Figs. 1 and 2). Spleen of medium size with deep incision of lower pole; 5 cm. splenic process from upper pole continuing as fibrous cord 7 cm. long, with small nodule of splenic tissue in upper portion. Cord inserted at left innominate line anteriorly. Splenic vessels normal. Normal testicles in scrotum. Other anomalies were: peromelus; slight micrognathia; absence of both forearms, hands, both lower legs, and feet; slight hypoplasia of right humerus and left femur; diagonal asymmetry of skull with prominence of right frontal and left occipital areas; congenital hydromelia; slight abnormal fissures of lungs and liver; urinary and fecal incontinence. Cause of death: bronchopneumonia. Was the second child; no family history of malformation.

17. von Hochstetter,[19] 1953. White female thoracopagus, probably newborn. Splenic cord from upper pole of spleen of left partner to slightly undescended left ovary, with two intra-ovarian splenic nodules. Blood and nerve supply to splenic nodules and cord from left ovarian artery and nerve. Abnormal fissures of main spleen. Three accessory spleens at hilus and one in gastrosplenic ligament. Other anomalies were: thoracopagus with single jejunum and upper ileum; Meckel's diverticulum with pancreas of left lower ileum; common truncus for celiac, superior mesenteric, and abdominal phrenic arteries; right umbilical artery of left partner missing.

18. Armed Forces Institute of Pathology Accession 547162. White female, stillborn (Figs. 3 to 7). Spleen 6 by 2.3 cm., in normal position with elongated process from upper pole attached to partly undescended left adnexa between tube and ovary. Process tapered to 0.5 cm. at lower end; cyst 0.5 cm. in diameter, on upper anterior portion. Tubes, ovaries, and uterus normal; no other internal congenital anomalies. Histologically, normal congested splenic tissue throughout; multiple blood supply of splenic process through hilus-like niches; fusion of lower pole of splenic process to ovary with intervening fibrous tissue; splenic cyst with capsule-like wall, mesothelial lining, and coagulated albuminous contents. Other anomalies were: hypoplasia of mandible (micrognathia); slight posterior rotation of ears; absence of both forearms and hands with nipple-like skin appendages anteriorly on each arm stump; absence of right lower leg and foot; fusion left great, second, and third toes; absence of left fourth toe. Full-term, 2,450 gm. stillborn with intracranial hemorrhage over right frontoparietal lobe; first pregnancy; no maternal diseases in first trimester except minimal vaginal bleeding.

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B. DISCONTINUOUS TYPE: SUMMARY OF 12 CASES

1. Finaly,[20] 1926. Male, newborn. Accessory spleen in left epididymis with congenital left inguinal hernia.

2. Talmann,[21] 1926. White male, 22 years old. Accessory spleen, 2.5 cm., in head of left epididymis; second fibrosed accessory spleen, 0.8 by 0.5 by 0.4 cm., on spermatic cord at external inguinal ring; histologically, splenic tissue with hyperplasia; scarring, with pigment prevailing in upper accessory spleen; old thrombosis of spermatic vein; atrophy of testicle; thickening of albuginea and tunica vaginalis; atrophy of vas. Tenderness and swelling of testicle after long marches (soldier); painful swelling of left testicle (size of goose egg) during malaria 4 months previously, receding to previous size after recovery.

3. Osselladore,[22] 1928, and Frasson,[23] 1942. White male, 19 and 30 years old at times of respective reports. Three masses of splenic tissue, largest, 4.7 by 3.9 cm., at lower pole of testis, deep red, covered by tunica albuginea with definite splenic capsule. Two smaller masses, wine red, attached to region of splenic-gonadal fusion by thin sheet of tunica vaginalis and floating free in scrotal cavity. Histologically,

* Information contributed by Prof. A. Werthemann, Basle, Switzerland.

largest splenic mass covered by tunica albuginea and splenic capsule; some fibrosis of pulp with hemorrhage; arterial supply through capsule and its septa. Atrophic changes in testis. Left testicle about twice normal size since birth, bilobed, with two small, soft, movable nodules attached. Exploration and biopsy of the two small nodules at age 19. Left orchiectomy at age 30.

4. Settle,[24] 1940. Male, age and race unknown. Tertian malaria with painful swelling of scrotal spleen, surgically removed. Case not reported, only mentioned in discussion.

5. Emmett and Dreyfuss,[5] 1943. White male, 47 years of age. Encapsulated accessory spleen, 4 by 2 cm., attached by broad base to albuginea of upper pole of testicle and head of epididymis, surgically removed. Testicle, epididymis, and spermatic cord appeared normal; histologically, normal splenic tissue, small follicles, hyperplastic red pulp. Right inguinal hernia repaired. Preoperative diagnosis: bilateral indirect inguinal hernia with tumor of left testicle.

6. Sartor,[25] 1948. White male, 9 years old. Walnut sized accessory spleen at inferior pole of left testicle. Histologically, splenic tissue. Found during medical inspection of school children. Surgically removed.

7. Gordeef and Cuenant,[26] 1951. White male, 9 years old. Surgical specimen: upper third, semilunar in shape and resembled testicle, separated by fibrous tissue from lower two thirds which was a firm, reddish, nodular mass. Spleen was situated between testicle and corpus of Highmore and head of epididymis, pushing latter two structures laterally. Microscopically, normal spleen and immature testis. Patient first examined because of right scrotal mass. Palpation revealed a heavy testicle about five times larger than a normal testicle, with an irregular, bosselated surface; epididymis and spermatic cord normal, but vaginal process could not be felt. No lymphadenopathy. General physical condition excellent. Preoperative diagnosis: malignant tumor.

8. Keizur,[16] 1952 (case 1). White male, 4 years of age. Accessory spleen, 3 by 5 by 2 cm., in upper pole of left testicle beneath tunica albuginea; histologically normal; spleen and testicle separated by thin, fibrous layer. Left scrotal mass, 3 by 5 cm., noted at physical examination preceding operation to correct cardiac malformation. Parents stated that mass was present at birth and had not changed in size. Left orchiectomy performed 1 month after successful Blalock procedure.

9. de Cesaris,[27] 1952. White male, 13 years old. Accessory spleen, 8 by 4 by 3 cm., at upper pole of testicle; histologically, spleen with hyalinization of arterioles. Left testicle larger than right since birth, gradually increasing in size. Painful on effort. Tender to palpation. Preoperative diagnosis: tumor of the testicle.

10. A.F.I.P. Acc. 121792. White male, 24 years of age. Accessory spleen, 4.5 by 2 by 1 cm., with smooth gray capsule save for one lacerated surface, located in excised upper half of left testicle; histologically, only splenic tissue with some fibrosis of stroma and decreased pulp. Lower half of testicle appeared normal and was not removed. Recurrent attacks of epididymitis and discomfort of left spermatic cord following herniorrhaphy in civilian life several years previously.

11. A.F.I.P. Acc. 317305. White male, 23 years old. Accessory spleen, 1.7 by 2.3 cm., in upper pole of left testicle, completely encapsulated; testis, epididymis, and vas normal; dilatation of pampiniform plexus; histologically, normal splenic tissue. Mass in left scrotum since 1945, recently increasing in size without symptoms; physical examination revealed upper third of enlarged left testicle to be firmer than normal but not tender.

12. A.F.I.P. Acc. 644069. Male, 11 years old. Race unknown. Admitted for tumor of the scrotum. Surgical specimen: ovoid, deep red, encapsulated mass, 1.5 by 1.4 by 1.1 cm.; surface smooth, cut section grayish pink; removed from soft tissue between scrotal skin and spermatic cord just above and lateral to testis. Microscopically, well defined capsule with many lymphoid follicles and follicular arteries suggestive of splenic tissue; elongated sinusoidal spaces lined by endothelium and

containing red blood cells; cords separating these spaces resembled cords of Billroth. The mass was traversed by fibrous septa resembling trabeculae, which contained blood vessels similar to those of the spleen. Diagnosis: accessory spleen, scrotum.

Clinical Observations

In Heitzmann's[4] case the spleen attached to the upper pole of the testicle was an incidental finding during the repair of a left indirect congenital inguinal hernia. In other cases the aberrant splenic tissue also was found during hernial repair or operation for undescended testicle. The aberrant splenic tissue gave rise to clinical symptoms in only a few cases. Talmann's[21] patient noticed tenderness and swelling of the left testicular area after long marches. The mass also became large and painful during an attack of malaria, receding to its former size after recovery. A similar response to malaria was observed in the case mentioned by Settle.[24] Occasional tenderness of the scrotal mass, first noted at the age of 3 years, was a prominent symptom in the case reported by Tate and Goforth.[15] Scrotal tenderness was also a symptom at 7 years in the case of Bennett-Jones and St. Hill[6] and at 9 years in the case of Gordeef and Cuenant.[26] Increasing pain and discomfort, with attacks of swelling during systemic infections in the 11 years after exploration and biopsy, were the indications for orchiectomy in the case of Osselladore[22] and Frasson.[23] Recurrent attacks of "epididymitis" and discomfort in the region of the left spermatic cord were observed in one of our cases after herniorrhaphy (A.F.I.P. Acc. 121792). The presenting symptom in Andrews and Etter's[14] case was pain in the left testicle. The enlargement had been present since birth and caused particular discomfort during strenuous exercise. These observations are of interest, since pain in the left hypochondrium after running or other violent exercise often has been related to splenic engorgement with painful capsular tension.

In a number of cases the scrotal mass or masses[22,23] were observed throughout life for varying periods; sometimes they had been present since birth and were believed to represent a third testicle[8,22,23] or a testicular tumor.[5,26,27] The only preoperative diagnosis of aberrant scrotal spleen with congenital left inguinal hernia recorded in the literature was made by Kadlic[12] (1943).

Relationship to Gonadal Descent

As is to be expected, the abnormal fusion of the spleen to the mesonephric-gonadal structures frequently interferes with the normal completion of gonadal descent and orderly closure of the processus vaginalis peritonei in the male. Of the 15 males with splenic cord, only 8 showed completely descended testicles. In one case[1] a left ab-

dominal testicle was located at the iliac fossa, in one[11] bilateral inguinal testicles were combined with congenital left indirect inguinal hernia, and in another[9] both testicles were at the external inguinal ring. In 4 cases the position of the testicles was not stated. Congenital left inguinal hernias were present in 4 cases of the continuous type.[4,6,11,12] In one of our cases of the discontinuous type (A.F.I.P. Acc. 121792), a left indirect inguinal hernia was found, but it was not stated specifically to be congenital. In the case of Emmett and Dreyfuss[5] a right congenital hernia was observed.

In the instances of continuous splenic cord in the female, complete inhibition of ovarian descent was apparent in our own case (A.F.I.P. Acc. 547162) and partial inhibition in von Hochstetter's[19] case.

Gross Anatomical Findings

All cases of the continuous type showed a cord of splenic tissue, appearing as if spun out of the spleen, that connected with the left testicle, epididymis, ovary, or mesovarium. The case of Werthemann and Roulet[18] was the only one in which it could be assumed that the cord terminated at the left innominate line anteriorly. In all cases in which the exact relationship of the cord to the spleen was described or illustrated, it arose from the cranial (upper) pole. Bennett-Jones and St. Hill,[6] however, described the cord in their case as arising from the region of the hilum of the spleen. In most cases the spleen was otherwise normally formed and located. Keizur[16] (case 2) described a two-lobed spleen, and von Hochstetter[19] mentioned abnormal fissuring and hilar accessory spleens. The cord usually tapered downward, often with a terminal bulbous mass of splenic tissue at the gonadal attachment. The cord was completely splenic, or partly fibrous, or beaded with multiple nodular masses of splenic tissue. Only von Hochstetter's case showed actual inclusion of two masses of splenic tissue in the ovary; Bennett-Jones and St. Hill found seminal tubules in the splenic tissue. In all other cases there was attachment only and no intermingling with the mesonephric-gonadal structures. The cord usually was seen as a free intraperitoneal structure, often traversing the abdomen anteriorly to the intestinal loops. The splenic vessels were found to be normal in every instance in which reference was made to their examination.

In cases of the discontinuous group the aberrant splenic tissue presented itself as a distinct encapsulated mass attached to the testicle or to the head of the epididymis. In Talmann's[21] case there were two and in the case of Osselladore[22] and Frasson,[23] three splenic masses in

the scrotum or on the spermatic cord. In no instance were remnants of a previously continuous cord seen on the isolated aberrant splenic tissue.

Histologic Findings

The splenic tissue of the cord as well as of the isolated aberrant masses sometimes was completely normal, although regressive changes, including fibrosis, thrombosis, calcification, thickening of trabeculae, and deposition of blood pigment, often have been noted. These changes may lead to complete fibrous replacement and formation of fat tissue in some portions of the splenic cord. In our case of continuous fusion (A.F.I.P. Acc. 547162) a peritoneal inclusion cyst was present in the upper portion of the splenic cord. Occasionally, subnormal differentiation into pulp and follicles and, sometimes, congestion of the pulp have been noted. In some cases the splenic tissue participated in the function of the main spleen, as is the rule with ordinary accessory spleens. In his case of perforated duodenal ulcer with peritonitis, Olken[13] found the scrotal spleen and also the main spleen in a state of inflammatory hyperplasia. Emmett and Dreyfuss[5] also noted hyperplasia of the red pulp.

The area of fusion is variously described as a thinned or thickened layer of fibrous tissue, occasionally enveloping the spermatic cord, the epididymis, or the testicle. The splenic tissue may or may not be completely covered by tunica vaginalis. The left testicle of Talmann's[21] patient was atrophic, fibrosed, and contained an increased number of Leydig cells. There was also old thrombosis of the left spermatic vein, atrophy of the left vas, and thickening of the tunica albuginea and the tunica vaginalis. Similar changes were noted by Tate and Goforth[15] in the atrophic left testicle of their 21-year-old patient.

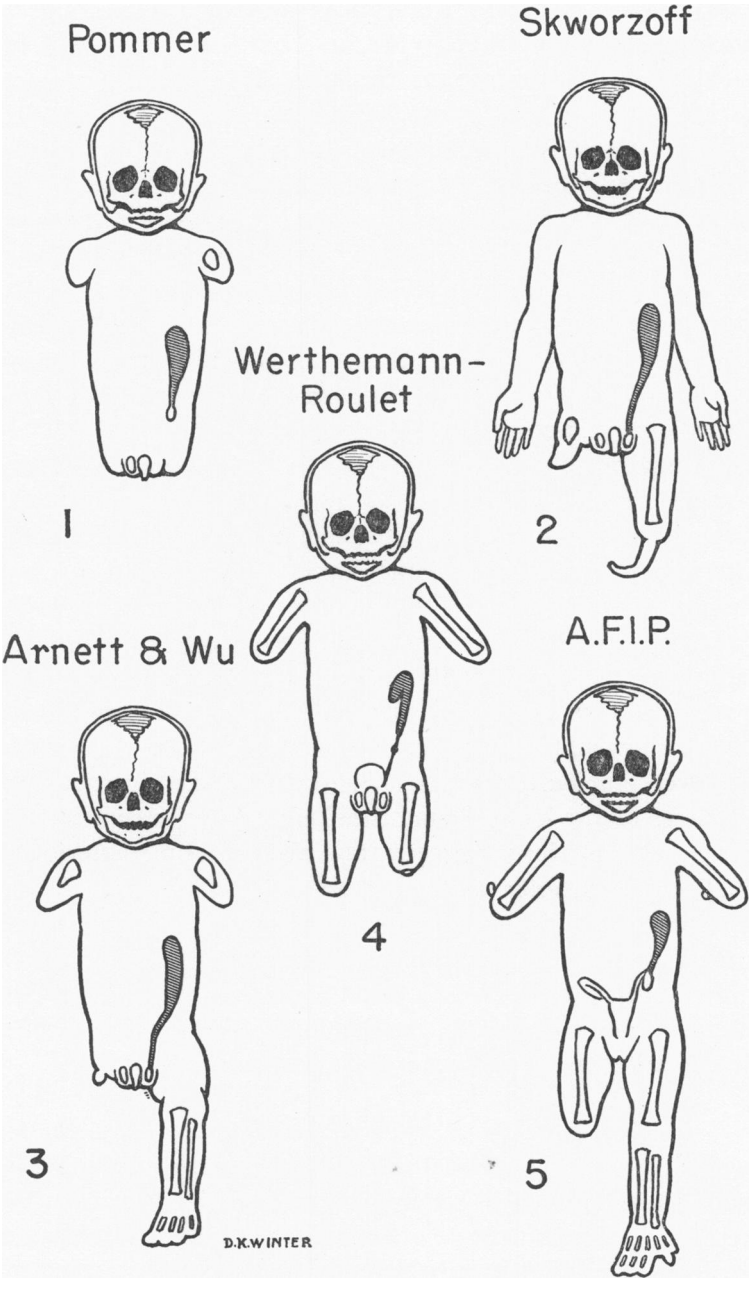
The splenic cord frequently contained a sizeable artery and vein running a longitudinal course, sometimes with multiple branches entering the cord through hilus-like niches, as in our own case (A.F.I.P. Acc. 547162). The relationship of the blood vessels and nerves in the splenic cord has been described in detail by von Hochstetter,[19] who based his observations on reconstruction of serial sections. He found that branches of the left ovarian artery and nerve supplied the intraovarian splenic nodules and the lower portion of the splenic cord. In Pommer's[1] case it was noted also that the left spermatic vein received a branch from the lower portion of the splenic cord, while a second left spermatic vein arose from the left testicle. In view of these findings the origin of the vessels supplying the splenic cord deserves more careful attention.

Embryologic Findings

The splenic anlage is formed in the left dorsal mesogastrium in the fifth week, in embryos of 8 to 10 mm. length, and consists of multiple, small masses which usually fuse to form one organ.[28] It is in intimate topographic relationship to the mesonephros and the gonadal anlage until gonadal descent and mesonephric involution begin at an embryonic length of about 20 mm. in the eighth week.[29] The origin of splenic-gonadal fusions must be dated in the period of close proximity of these structures. At present, the cause remains obscure. It is debatable whether this faulty union is brought about by fusion across the separating coelomic epithelium, as most investigators assume. Von Hochstetter[19] favored the assumption that the derivatives of the urogenital fold and the splenic anlage unite by means of the caudal terminating fold, which is intimately related to the diaphragmatic pillar of Uskow. If this were the case, the coelomic space would not have to be bridged. He believed that the intimate intermingling of splenic and ovarian circulation and innervation in his case favored this explanation rather than that of mere fusion. On the other hand, the analogy with dystopic displacement of adrenal cortical nodules along the mesonephric-metanephric derivatives, including gonads, mesosalpinx and epididymis, cannot be ignored. It is open to speculation whether the discontinuous fusions are derived from an isolated hump of the splenic anlage — as some accessory spleens undoubtedly are — or whether the connection with the main spleen, originally present, has been lost, leaving no vestiges. The observations seem to favor the first assumption.

Relationship to Peromelus and Micrognathia

Special emphasis should be given a syndrome of rare malformations which appears rather frequently in combination with the continuous type of splenic-gonadal fusion. Five of the 18 cases showed severe degrees of peromelus and in 3 of these micrognathia was an additional feature. The combination of defects of the extremity (peromelus) and hypoplasia of the mandible (micrognathia) has been observed repeatedly, particularly by Gruber.[30] In this group there were 5 such cases; 4 male[1,9,17,18] and one female (A.F.I.P. Acc. 547162). In all of these, severe malformations and defects of the extremities were present. The details are given in the condensed summaries and in the schematic drawings of these 5 cases (Text-fig. 2). The common denominator for these rather heterogeneous malformations is the time of critical de-



Text-figure 2. Diagrammatic sketch made from the information available on the five reported cases of peromelus associated with splenic-gonadal fusion. Micrognathia is present in the cases of Pommer,[1] Werthemann and Roulet,[18] and the A.F.I.P. Acc. 547162.

velopment. In a fetus of 17 mm. in greatest length the buds of the extremities are differentiating; Meckel's cartilage—the mold for the bony mandible—is forming, and the spleen is in intimate contact with the mesonephric-gonadal anlage. This stage of development is illustrated by serial sagittal sections of a 17 mm. embryo from our own collection (Figs. 8 to 11). A more diffuse but still not fatal injury to the fetus at this time could produce the syndrome of splenic-gonadal fusion, peromelus, and micrognathia. Recently Mushett[31] has shown experimentally on chick embryos that short periods of anoxia produce peromelus combined with malformations of eye, brain, and spinal cord. It is interesting in this connection that the patient of Werthemann and Roulet[18] showed hydromyelia of the cord in addition to splenic-gonadal fusion, peromelus, and micrognathia.

Malformations other than those included in the syndrome described above were observed in only 3 of the 18 cases of continuous fusion and in none of the 12 cases of discontinuous splenic-gonadal fusion. Peromelus was a feature in 2 of these 3 cases. In Pommer's[1] case a defect of the coccyx and atresia of the anus were present. The patient of Werthemann and Roulet[18] showed diagonal asymmetry of the skull and abnormal fissures of lung and liver. Von Hochstetter's[19] observations were made on an old museum specimen of thoracopagus without peromelus (it would appear from the picture that the extremities had been severed previously), which showed a Meckel's diverticulum, with the pancreas on the lower ileum of the left partner, a common truncus for the celiac, superior mesenteric, and abdominal mesenteric and abdominal phrenic arteries, and absence of the right umbilical artery of the left partner. This small yield of other malformations compared with the frequent combination of splenic-gonadal fusion, peromelus, and micrognathia, each rare by itself, again emphasizes that this syndrome represents an intrinsic combination reflecting the time of action of the causative factor and not a mere chance association.

Summary

Twenty-six cases of gonadal-splenic fusion collected from the literature have been studied in conjunction with 4 new cases from the files of the Armed Forces Institute of Pathology. This malformation occurs in two forms: continuous, in which the main spleen is connected by a cord of splenic and fibrous tissue to the gonadal-mesonephric structures, and discontinuous, in which discrete masses of splenic tissue are found fused to these same structures.

Study of this malformation in its embryologic aspects indicates that

it has its origin between the fifth and eighth weeks of embryonic life.

Peromelus was observed in combination with splenic-gonadal fusion in 5 of the 30 cases, and in 3 of the 5 micrognathia also was present. This association of rare malformations in almost one fifth of the series constitutes evidence of a syndrome, since it occurs in too high a percentage of cases to be an effect of chance.

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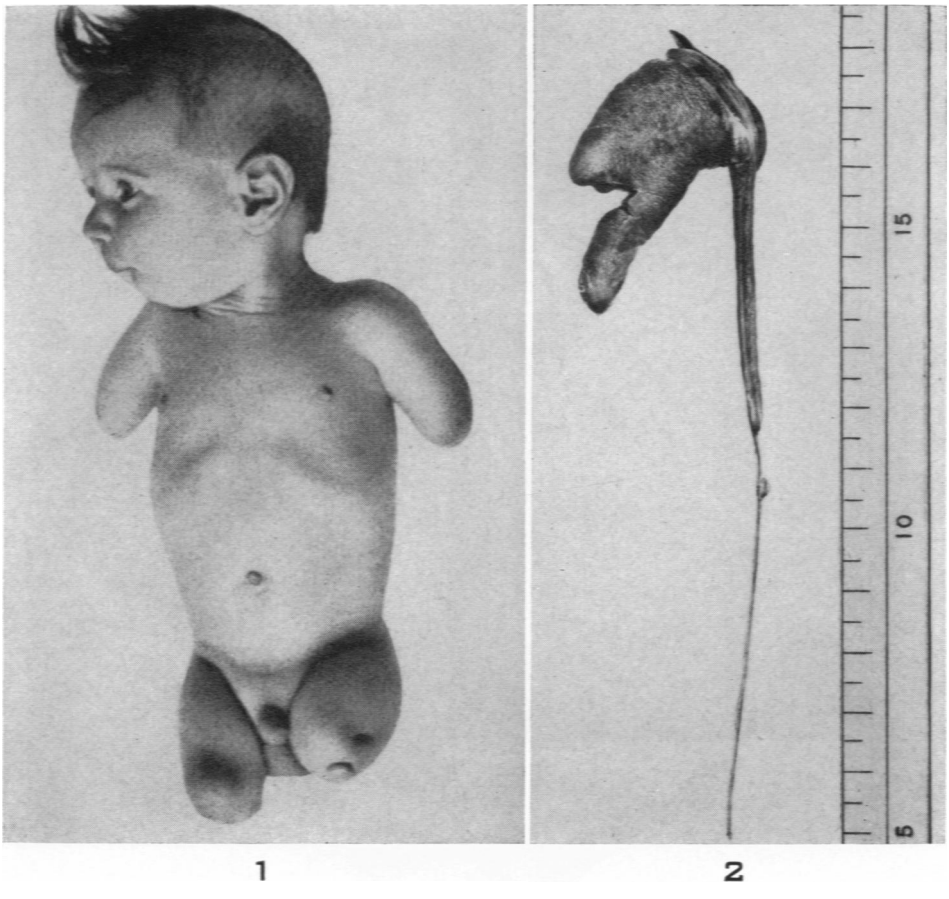
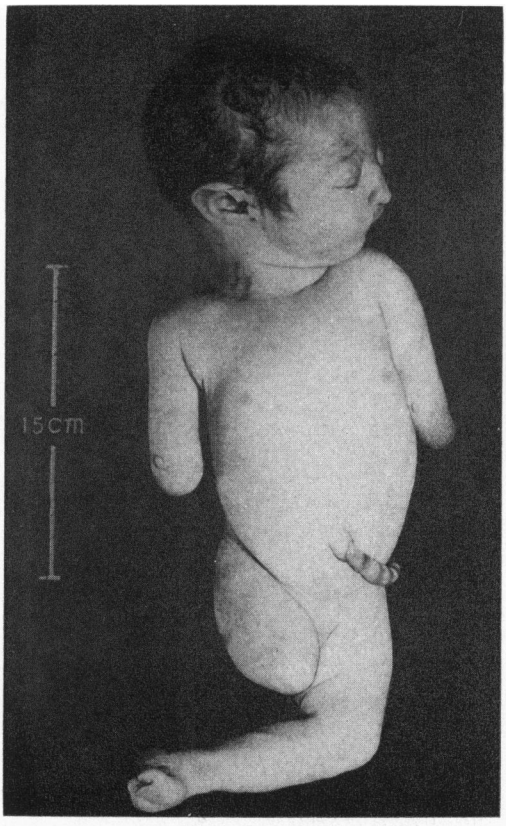


1 2

LEGENDS FOR FIGURES

FIG. 1. Clinical photograph of the case of Werthemann and Roulet.[18] (Supplied by Professor E. Freudenberg, Children's Hospital, University of Basle, Switzerland.)

FIG. 2. Splenic-gonadal fusion in the case of Werthemann and Roulet.[18] (Supplied by Professor A. Werthemann, Department of Pathologic Anatomy, University of Basle, Switzerland.)



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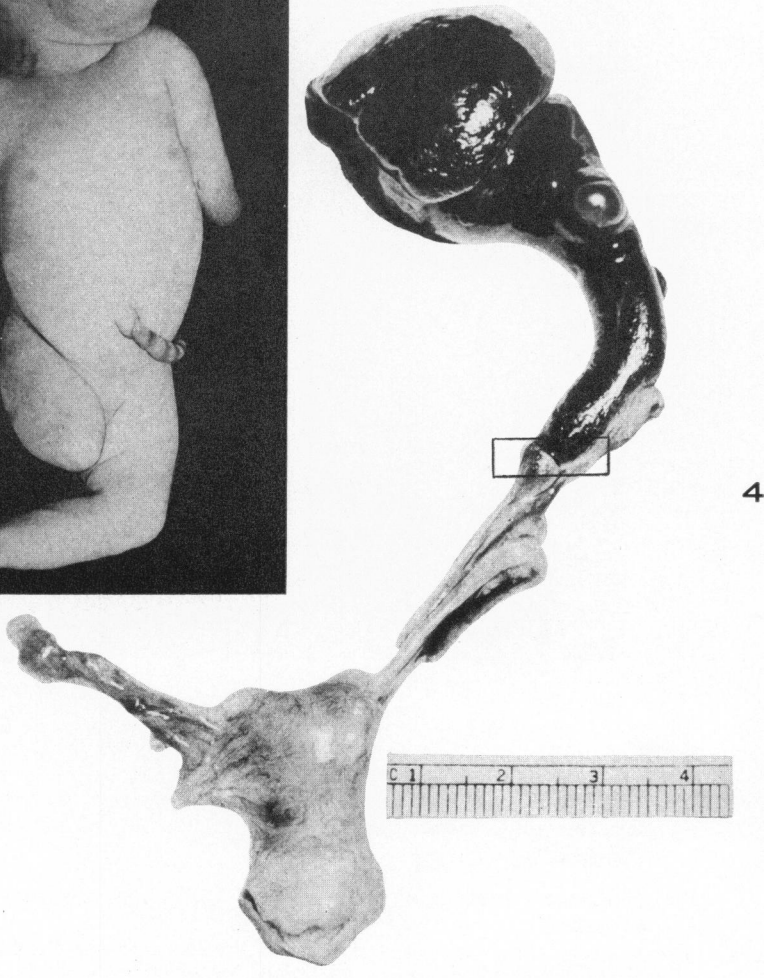

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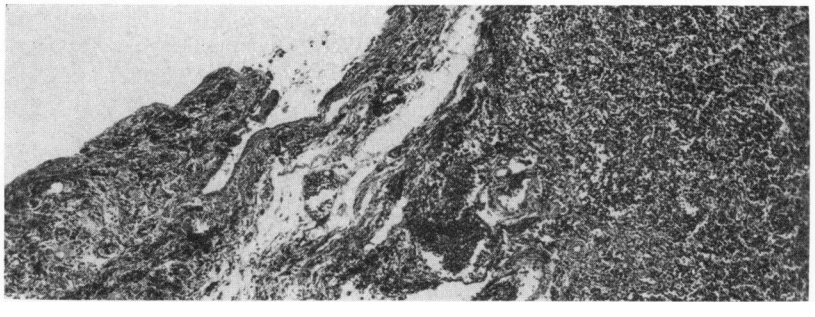

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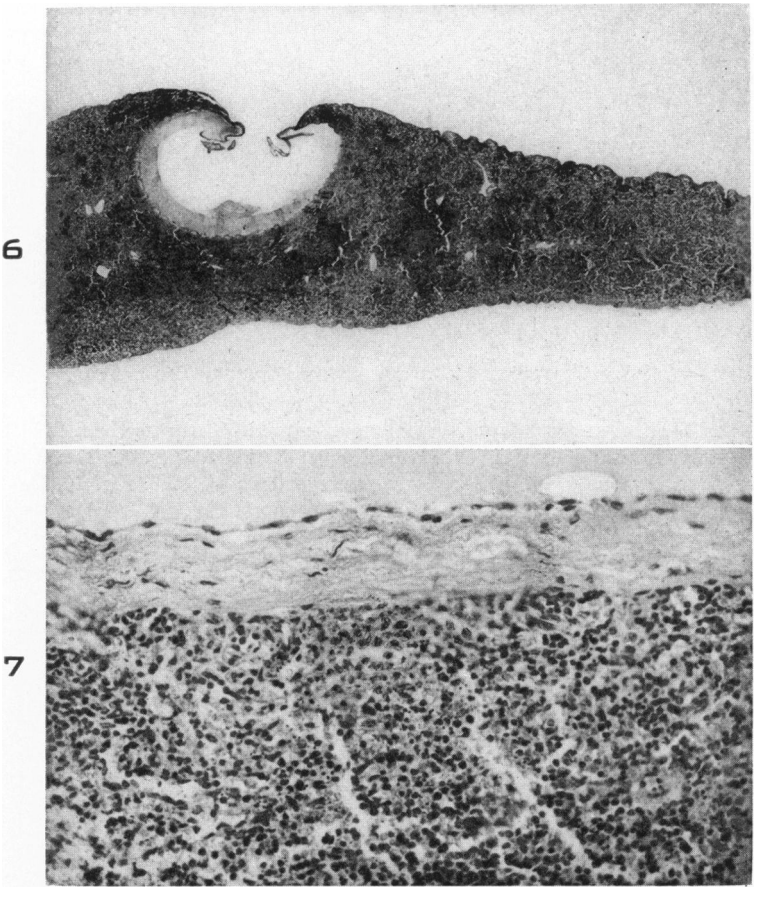


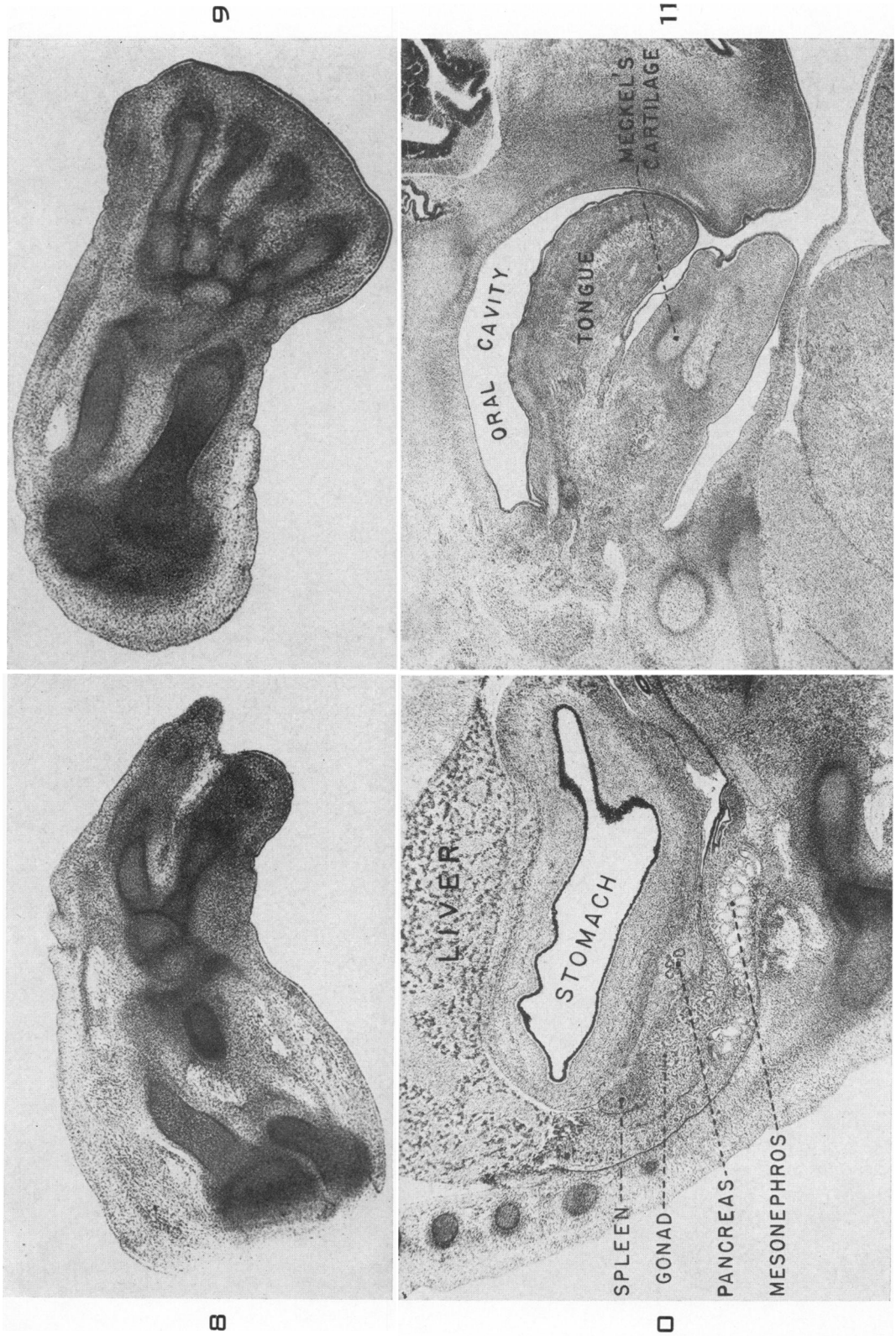
FIG. 3. Armed Forces Institute of Pathology Accession 547162, showing absence of both forearms and hands and of the right lower leg and foot (peromelus) with micrognathia.

FIG. 4. Photograph of splenic-gonadal fusion (same case as that from which Fig. 3 was taken).

FIG. 5. Section through the side of the splenic-gonadal fusion as indicated by the rectangle in Figure 4, showing the ovary on the left and the spleen on the right. × 75.

FIGS. 6 and 7. Same case as that from which Figures 3, 4, and 5 were taken. *Fig. 6.* Section through splenic cyst. × 10. *Fig. 7.* Section through wall of cyst showing cell-lining in a single layer with outer fibrous connective tissue wall. × 48.

FIGS. 8 to 11. Sagittal sections from a serially cut 17 mm. fetus from the files of the Charleston General Hospital, Charleston, West Virginia. *Fig. 8.* Developing upper extremity bud. *Fig. 9.* Developing lower extremity bud. *Fig. 10.* Developing gonad and spleen in close proximity to each other. *Fig. 11.* Developing Meckel's cartilage.


9
11
ORAL CAVITY
TONGUE
MECKEL'S CARTILAGE
8
10
LIVER
STOMACH
SPLEEN
GONAD
PANCREAS
MESONEPHROS